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TECHNICAL RESEARCH REPORT 1128

**Selection of Anti-Tank
Missile Gunners--**

Status Report, 30 June 1962

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US ARMY PERSONNEL RESEARCH OFFICE
(An Activity of the Chief of Research and Development)

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**Army Project Number
OJ95-60-001**

Anti-Tank Guided Missile Task

**USAPRO Technical Research Report 1128
SELECTION OF ANTI-TANK MISSILE GUNNERS--
STATUS REPORT, 30 JUNE 1962**

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June 1962

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BRIEF

SELECTION OF ANTI-TANK MISSILE GUNNERS-- STATUS REPORT, 30 JUNE 1962

Requirement:

USCONARC and the Army Missile Team at Fort Benning, Georgia requested USAPRO to assist in selecting men for SS-10/11 training scheduled to begin in January 1960 in the interest of improving gunner trainee proficiency.

Procedure:

A preliminary battery was selected from a large number of experimental instruments. Composition of the battery was based on results attained in a sample of 36 trainees making up experimental classes for a HumRRO study of effect of training sequence on simulator performance. In the absence of actual firing records, an administrative recommendation served as criterion for test selection.

To select a final battery, more realistic criterion measures of gunner performance were developed through consideration of varying difficulty of environmental conditions at time of missile firing.

Accomplishments to Date:

Three tests were selected to make up the preliminary battery for selection of gunner trainees: Pattern Analysis of the Army Classification Battery, Coordinate Movements, and Locations (double weighted).

Predictor and gunner performance criterion data have been obtained for a more comprehensive validation study of experimental measures. Data are now being analyzed to identify the most effective predictors for a final selection battery.

Utilization of Findings:

A preliminary battery was used to select gunner trainees for eight 1960 classes in the operation of SS-10 weapons systems. Cross-validation of the battery selected as a result of the present study is desirable in order that a means of selecting gunner trainees may be available if need arises.

SELECTION OF ANTI-TANK MISSILE GUNNERS--
STATUS REPORT, 30 JUNE 1962

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**SELECTION OF ANTI-TANK MISSILE GUNNERS--
STATUS REPORT, 30 JUNE 1962**

RESEARCH REQUIREMENT

The SS-10/11 missile systems belong to a family of Army weapons characterized by a wire-guided control system, man-operated rather than computer-controlled throughout the flight of the missile. The fact that a man, rather than an automatic control device, is charged with quick, accurate adjustment of the missile trajectory places an unusual requirement upon the human operator--a requirement that differs significantly from that of firing a traditional weapon with relatively well defined ballistic trajectory.

In June 1959, the U. S. Army Personnel Research Office was requested by the Missile Committee at Fort Benning, Georgia and USCONARC to assist in the selection of personnel for SS-10/11 training. Standards for trainee gunners were required in view of the high quality of performance essential to control of these weapons systems. The high cost of practice firings was an added consideration. Because selectors were required for operational use at the beginning of training in January 1960, only limited research could be completed for the immediate objective. Concomitantly, however, groundwork was laid for development of a selection battery based on a complete validation study.

PRELIMINARY SELECTION BATTERY

A set of selection instruments was assembled and tried out on a small sample undergoing training at Fort Knox, Kentucky from October to December 1959. The sample consisted of 36 members of three successive training classes set up by the Armor Unit of the Human Resources Research Office (HumRRO) to investigate the effects of various training sequences on simulator performance (HumRRO Firepower VII study). Trainees were volunteers for airborne training who had just completed paratrooper training.

Choice of experimental instruments for the USAPRO validation study was guided in part by results of a previous (March 1959) HumRRO pilot study on the selection of SS-10 gunners. The Rotary Pursuit Test was used as the basis for selecting 11 gunners from a sample of 60. Eight additional psychomotor tests were administered experimentally to the 11 gunners selected. Of the nine measures, two--Aperture Steadiness and Groove Steadiness--showed promise as predictors of performance on a training simulator (Follettie, Abbott, Felton, and Garee, 1959).

In developing the USAPRO preliminary battery for gunner selection, 27 measures were evaluated as predictors of gunner performance, including four tests borrowed from selection batteries for Army fixed-wing and rotary-wing aviator trainees, the Rotary Pursuit Test, the Steadiness tests which had shown promise in the HumRRO pilot study, the 11 tests of

the Army Classification Battery and three aptitude area composites-- General Technical, Infantry (Combat), and Artillery-Armor-Engineer (Combat). Brief descriptions of all experimental predictors are given in the Appendix to the present report.

The criterion was in the form of an administrative recommendation either to allow or not to allow the individual to complete missile gunner training when the program was expanded. Recommendations were decided upon at the close of each two-week training course by a Missile Team composed of Infantry School gunner instructors. All experimental predictors were correlated with the dichotomous criterion measure separately for each group of 12 trainees and for the total group of 36. The four resulting coefficients per variable were examined for magnitude and consistency. Consideration was also given to the nature of the tests in light of their past uses and in terms of the task involved in gunner performance. Three tests--the Pattern Analysis Test of the Army Classification Battery, Coordinate Movements, and Locations--were selected to make up the interim selection battery. In the selector composite, the Locations test receives double weight; Pattern Analysis and Coordinate Movements are unit-weighted.

Administrative Use of the Preliminary Battery

During 1960, the preliminary battery was used primarily to select trainees for eight SS-10 classes conducted by the U. S. Infantry School at Fort Benning. There were 30 applicants for each of classes one through five, 29 for class six, and 25 for each of classes seven and eight. In selecting trainees for each class the men were ranked in order of composite score on the selection battery. A recommendation was made by USAPRO that individuals be selected from the highest ranking down until the class was filled. The recommendation was followed with few exceptions in selecting the 15 individuals accepted for training in each class. Also during 1960, the Seventh and Eighth Armies were granted permission to use the battery. Permission was also granted for the battery to be translated into Greek for use in the Hellenic Army.

RESEARCH TO DEVELOP A FINAL SELECTION BATTERY

Basis for the Study

Findings from the validity study in which the interim battery was selected were considered tentative in view of the small sample and the summary nature of the criterion. A full-scale validation of the same experimental predictors (see Appendix) on a larger sample was undertaken. In this study, all eight aptitude area measures were analyzed.

The best available sample was provided by the first six SS-10 classes conducted by the Infantry School at Fort Benning from February

through September 1960.^{1/} The 90 trainees in these classes had been selected on the interim battery from 180 applicants representative of the population defined as all applicants for SS-10 training who meet the following prerequisites:

MOS 111 or 112

Physical profile A

Uncorrected vision 20/20

Expiration term of service one year after end of SS-10 training

Eligibility for interim CONFIDENTIAL security clearance

Score of 90 or above on General Technical Aptitude Area

Through progressive elimination during the five weeks of training, the analysis sample was ultimately reduced to 30 gunner candidates who completed the course.

Framework for Criterion Development

The major problem in selecting effective predictors has been the determination of a suitable measure of gunner success. The simulator criterion used in the earlier HumRRO study was unsatisfactory because its relationship to performance in actual missile firing was unknown. In developing the interim battery, a dichotomous rating criterion was used in the absence of actual firing records. In the training which provided a framework for the present study, men who completed the course fired a limited number of missiles. Several other measures of trainee performance were available. To convey an understanding of the advantages and limitations surrounding each measure as a criterion of performance, a brief description of the gunner's task and of the training he was given is provided.

The Weapons Systems

The most widely used of the direct-fire wire-guided missiles has been the SS-10, developed by the French and adopted by most of the NATO nations. The SS-10 missile is a light, self-propelled, auto-rotating, remote-control guided missile intended for use against ground targets. It is primarily an anti-tank weapon but can be used effectively against personnel, gun emplacements, roadblocks, and fortifications. The missile is brought into alignment with and guided toward the target by the gunner

^{1/}Training in classes seven and eight in which various training methods were being studied by HumRRO differed markedly from that in the first six classes.

who generates the guidance commands by means of a manually operated control stick. Transmission of commands from the guidance equipment to the missile is effected by two electrical wires which unwind from within the missile during its flight.

The missile is launched and propelled by two solid propellant rocket motors. The booster motor launches and accelerates the missile to its required velocity; the sustainer motor maintains the missile at its cruising speed. The SS-10, equipped with an instantaneous fuse which detonates the warhead on impact, can be launched from the ground, from a vehicle, from a helicopter or other aircraft flying slowly at low altitude. Total weight of the missile, warhead included, is 33 pounds. The cruising speed is subsonic.

Evaluation During Training

The training consisted of exposure to two types of simulator. The S-55 is a green oscilloscope-type screen on which a pip of light simulates the tracking flare of a missile. The DX-40 also presents a pip of light, but does so on a still or moving picture of actual terrain. The guidance equipment is the same as is used for control of an actual missile. After two weeks of training in learning and practicing fine guidance control on the simulators, one-third of each class (five men) were designated ammunition handlers. Choice of the ten men to continue gunner training was based on demonstrated ability on the two simulators. Performance measures available through this stage of training are critiques of five of the first 20 training sessions on the S-55 and three of the first eight sessions on the DX-40.

For the remaining ten men, simulator training continued until the end of the fourth week, at which time they fired and controlled 20 consecutive shots on the S-55 and a like number on the DX-40. These trials were critiqued; in addition, two objective measures were taken of the 20 S-55 trials. One measure--guidance speed--was the total amount of time the pip of light was on the target. The other--steadiness of control--was the number of times the pip of light left the target after having landed on it initially.

Practice Firings

The ten remaining trainees then went on to the range to fire six practice missiles, two a day every other day. Days between range firings were spent in simulator practice on weak points discovered during range firing. After each man had fired six missiles, five of the men were designated assistant gunners, and the remaining five were designated gunner candidates. The gunner candidates each fired seven more missiles for a total of 13. Each round was critiqued in the same

manner as the simulator shots. In addition, individuals were rated on each round for overall control (A = good; B, C, D; F = poor). Environmental conditions existing at the time of firing were also recorded.

Conceptualization of the Criterion

In terms of missile gunnery, the criterion of ultimate interest is whether the individual can guide the weapon so that a target is damaged or destroyed. Available records and critiques of simulator performance during training were acknowledged to be only indirect approaches to the ultimate criterion. The decision was made to concentrate criterion development upon a direct measure of missile firing performance.

In the Fort Benning study, the 30 assistant gunners participated in six range firings, the 30 gunners in 13. However, initial analysis of the data indicated that measures based on number of hits or on proportion of shots which were hits did not reliably differentiate skill differences among individuals. Several characteristics of raw hit-miss scores may contribute to ineffectiveness of the measures as a criterion of individual differences. In the first place, the score is recorded as a dichotomy; that is, in the case of a miss, there is no indication of the extent to which the missile went wide of the target. Second, too few shots may have been made by the gunners to allow individual differences in gunner skill to emerge. The number of missiles fired is, of course, a restriction imposed by the expense involved in each firing. A third consideration is the lack of uniformity of conditions surrounding shots made by different persons as well as shots made by the same person. This difference in firing conditions may tend to obscure any individual differences present in the sample. USAPRO conceptualization of criterion construction developed on the basis of this last consideration--the varying conditions under which missiles are fired.

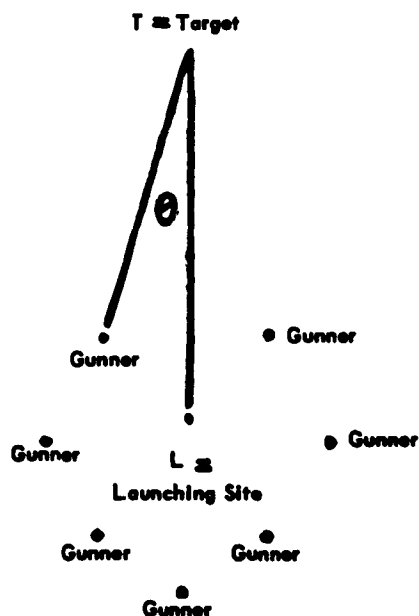
The gunner's task represents an extreme departure from the firing of traditional weapons. The major difference is the considerably longer period during which the gunner controls the flight of the missile. During this period the gunner may be influenced by many environmental factors, such as distance of target from gunner, movement of the target, visibility of the target, etc. Analysis of engineering and user test shot records performed for several ATGM systems (SS-10, SS-11, and ENTAC) revealed that the combination of environmental conditions existing at the time a shot was made did indeed exert an influence upon the outcome of the shot. In effect, shots made under varying sets of conditions are of unequal difficulty, an experimental condition which would add error to a hit-miss score.

However, if the difficulty of each shot is controlled to allow comparison of individuals on a common base, error in the scores could be reduced. Two methods of allowing for variations in the difficulty of the shots appeared feasible: (1) statistically equating the influence of

extraneous factors on each shot, and (2) placing on the rater critiquing each shot responsibility for considering conditions under which the shot was fired in judging the effectiveness of the gunner's control of the missile.

Adjusted Hit-Miss Score

The following method was developed for statistically correcting the hit-miss score on a given round for varying difficulty. Environmental and situational variables that could affect gunner performance are indicated in the following diagram.



The variables used in the score adjustment procedure were defined as follows:

1. Trial. The learning trial on which the shot was fired.
2. Range. Distance from launching site to target.
3. Angle of launch. Angle of elevation of the missile above the horizontal prior to launching.
4. Target movement. Stationary or moving during flight of the missile.
5. Deviation angle. Angle θ subtended by G - L side of triangle.

6. Jeep. Jeep housing of gunner control box at launching site.
7. Ground. Gunner control box at ground level, at a distance (G - L) from launching site.
8. Foxhole. Gunner control box in foxhole at a distance (G - L) from launching site.

Relationship of the variables with one another and with the hit-miss dichotomous score was first ascertained. From these interrelationships the relative influence of each variable upon the score was determined. It was then possible to adjust the score for each shot for the difficulty of the conditions under which it was performed. For example, a shot which resulted in a hit, fired at a difficult range, at a moving target, and at a difficult launching angle resulted in a higher score than a hit fired under easier conditions. Finally, the adjusted scores on all shots were summed to obtain an adjusted total score for each gunner or assistant gunner on a firing round. This score was considered a measure of range firing skill after the extraneous element of unequal firing conditions had been statistically allowed for.

Rating Criterion

Use of a rating criterion was predicated on the assumption that, in rating performance on a shot, the rater made a mental accounting of varying conditions affecting the shot. Each range firing was critiqued by two raters on a standard form listing 24 possible errors that could be committed by the operator. Errors listed were considered crucial in missile trajectory by the Fort Benning Missile Team. In addition, each range firing round was given a rating for overall control on a five-step scale--A, B, C, D, and F (A being good control and F being poor control).

A matrix of intercorrelations among the 24 critique items (each scored 0 or 1), the letter rating (scored 1 to 5), and hit-miss scores (0 or 1) was computed. The point biserial coefficient between the letter rating and hit-miss was .54. A multiple correlation of letter rating plus seven critique items raised the correlation coefficient to .61. Since adding predictor variables to the letter rating accounted for only a small amount of additional variance, attention was subsequently restricted to the letter rating as a criterion of gunner proficiency.

In sum, three criterion measures have been defined for use in selecting predictors for the final gunner selection battery:

1. Missile hit-miss for each round of shots, corrected for varying difficulty of environmental conditions
2. Overall five-step rating of each gunner on each round
3. Missile hit-miss raw score

Planned Validity Analysis

The final step in developing the gunner selection battery will consist in determining the most valid predictors of the three criteria, taken separately. Relationship between the selected predictors and each of the criteria will be described by multiple correlation. The matrix will include the 32 predictors and the three criterion variables. The sample for the matrix will be the 30 men who emerged from the training course as gunner candidates. Because these 30 gunner candidates are a restricted group out of the original 180 applicants for training, statistical correction to approximate the original group is necessitated. Also, because elimination of individuals occurred at several stages--on the basis of the interim battery, after a given number of simulator trials, and after six range firings--a multi-stage correction for restriction in range is called for.

RESEARCH PLANS

Statistical analysis is currently under way to select the final battery. Future use of the wire-guided manual-control ATGM systems as now envisaged does not appear to justify a large-scale continuation study. At the least, however, it would be desirable to cross-validate or refine the battery selected under the present research task so that an effective means of selecting gunner trainees would be at hand in the event of mobilization.

The most crucial prerequisite to additional productive research is the identification of a satisfactory criterion of performance for gunners in weapons systems of the type of the SS-10/11 and ENTAC. While the ANTI-TANK GUIDED MISSILE Research Task terminated at the end of FY 1962, analysis and reporting phases of the research were to be completed under USAFRO's FUTURE COMBAT Research Task.

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Follettie, D., Abbott, P., Felton, D., and Garee, M. Initial development of a test battery for selection of the SS-10 anti-tank guided missile gunner. United States Army Infantry Human Research Unit. Fort Benning, Georgia. Research Memorandum Number 10. 1959.

SS-10 Anti-Tank Guided Missile Platoon Training Circular, Annex O. United States Army Infantry School. Fort Benning, Georgia. March 1951.

APPENDIX

PREDICTOR VARIABLES ANALYZED IN DEVELOPING PRELIMINARY AND FINAL FORMS OF THE SELECTION BATTERY FOR SS-10 ATGM GUNNER TRAINEE CANDIDATES

All variables, with the exception of five aptitude area composites of the ACB (r's 26-30, inclusive) were analyzed in both developmental studies.

1. Two-Hand Coordination (PT 2617). A psychomotor test in which the examinee is required to use left hand and right hand alternately in placing a stylus point in successive circles on the test sheet. Circles are arranged in three separately lined sections. Testing time: 75 seconds. Score: Number of points within or touching the perimeter of circle.

2. Aircraft Orientation (DA Form 6237). Consists of 28 five-choice picture items dealing with ability to visualize the relationship between an airplane and the territory over which it flies. Planes are shown in silhouette. Testing time: 10 minutes. Scoring formula: $R - 1/4 W$.

3. Locations Test (PT 2852). A 24-item visual test consisting of sets of four small photographs, each set being accompanied by a large photograph in which locations are lettered. Examinee is required to identify the lettered location in the large photograph from which each of the small photographs was taken. The small photographs are darkened to give a "night" effect. Testing time: 12 minutes. Scoring formula: Rights only.

4. Coordinate Movements Test (PT 3076). Requires the examinee to judge distances and visualize movements quickly and to relate distances and movements to a set of symbols. Testing time: 10 minutes. Scoring formula: $R - 1/4 W$.

5. Stick and Rudder Orientation Test (PT 3175). A 30-item speeded test in which the examinee is presented with three photographs taken from the cockpit of a plane doing simple maneuvers (banking, turning, climbing, diving) or combinations of maneuvers (turning while climbing, for example). Examinee is required to relate the maneuvers shown to stick and rudder positions printed on the answer sheet. Testing time: 10 minutes. Scoring formula: $R - 1/4 W$.

6. Aiming Test (PT 3385). Examinee is required to make one dot in each of the many circles 1/8-inch in diameter, working as fast and as accurately as he can. Testing time: 50 seconds. Score: Number of circles dotted correctly (dots within or on perimeter).

7. Tapping Test (PT 3384). Examinee is required to make three dots in each of many circles 1/2-inch in diameter, working as fast and as accurately as he can. Testing time: 2 minutes. Score: Number of circles dotted correctly (within or on perimeter).

APPARATUS TESTS

8. Rotary Pursuit Test. An apparatus test of hand-eye coordination. Examinee is required to keep a stylus in contact with a small metallic surface set into a rapidly revolving disc which can be rotated at 30, 60, or 90 rpm. The apparatus provides for alternating rest and testing periods of 20 seconds each. Score: 1 to 20 for each of three trials, representing number of seconds stylus is on target.

9. Groove Steadiness Test. As a test of hand-eye coordination, examinee is required to push a stylus through a gradually narrowing groove without touching the sides of the groove. Whenever the stylus touches a side of the groove, a buzzer sounds. Score: Distance traversed by stylus before any contact is made.

10. Aperture Steadiness Test. This apparatus to test degree of control of muscular tremor consists of a stylus and a metal plate with nine holes (diameter in 64ths of an inch: 32, 16, 13, 11, 10, 9, 8, and 7). Examinee attempts to thrust stylus into each hole without making contact with the edge. Two scores are obtained: Number of contacts and hole on which first contact was made.

TESTS OF THE ARMY CLASSIFICATION BATTERY

11. Verbal Test (VE)
12. Arithmetic Reasoning Test (AR)
13. Pattern Analysis Test (PA)
14. Mechanical Aptitude Test (MA)
15. Army Clerical Speed Test (ACS)
16. Army Radio Code Aptitude Test (ARC)
17. Shop Mechanics Test (SM)
18. Automotive Information Test (AI)
19. Electrical Information Test (ELI)
20. General Information Test (GIT)
21. Classification Inventory (CI)
22. Driver Battery I

APTITUDE AREA COMPOSITES

23. GT--General Technical: $\frac{VE \text{ plus } AR}{2}$
24. IN--Infantry (Combat): $\frac{AR \text{ plus } 2CI}{3}$
25. AE--Artillery-Armor-Engineer (Combat): $\frac{GIT \text{ plus } AI}{2}$
26. EL--Electronic: $\frac{MA \text{ plus } 2ELI}{3}$
27. GM--General Maintenance: $\frac{PA \text{ plus } 2SM}{3}$
28. MM--Motor Maintenance: $\frac{MA \text{ plus } 2AI}{3}$
29. CL--Clerical: $\frac{VE \text{ plus } 2ACS}{3}$
30. RC--Radio Code: $\frac{VE \text{ plus } 2ARC}{3}$

REFERENCE VARIABLES

31. Age. Months to last birthday.
32. Education. Last grade completed.

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Pattern Analysis of the ACB, Coordinate Movement, and Location--were
chosen as an interim selection battery. In absence of actual firing
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